ORIGINAL RESEARCH PAPER

Prosthodontics

APPLICATIONS OF NANOMATERIALS IN PROSTHODONTICS-A REVIEW

KEY WORDS: Nanomaterials, Nanotechnology, Applications, Prosthodontics

Dr. Kalpana D

Professor & HOD Dept. of Prosthodontics, Dayananda Sagar College of Dental Sciences and Hospital, Kumaraswamy Layout, Bengaluru -560078.

ABSTRACT

Nanomaterials have been developed promptly and some researchers of nanomaterials have been carried out on Prosthodontics. Many of the current dental materials are available through nanocrystallization to improve their original performance and play key role in Prosthodontics.

INTRODUCTION

'Nano' is derived from the Greek word which means Dwarf . Nanotechnology is the art and science of material engineering at the nanoscale size (1-100nm). In 1959, famous American Physicist, Dr Richard Feynman seeded the concept of Nanotechnology. However, in 1974, Taniguchi was the first to use the word.The ongoing research in the realm of nano is due to the unique structure and properties of nanoparticles thus gaining high impetus in their applications.

In Prosthodontics, nanoparticles are added to acrylic resins, ceramics, tissue conditioners and soft liners, impression materials, maxillo – facial prosthesis, implants, since they modulate these materials to nanosize has given greater efficacy and durability.

SYNTHESIS OF NANOPARTICLES

The three approaches in the synthesis of Nanoparticles are:

1. Bottom up: This approach includes miniaturization of material components up to atomic level with further self assembly process leading to the formation of nanostructures. It starts with atoms or molecules to build up Nanostructures. For e.g. Nanodentifrices, tooth repair, diagnosis of oral cancer.
2. Top down: This approach uses larger initial structures which can be externally controlled in the processing of nanostructures. For e.g. Impression materials, nanoneedles, nanosolutions.
3. Functional: This approach does not give importance to the method of production of nanoparticles. Its objective is to produce nanoparticle with a specific functionality.

APPLICATIONS OF NANOMATERIALS IN PROSTHODONTICS

POLY METHYL METHACRYLATE (PMMA)

PMMA resin has been widely used as a denture base material, However owing to the surface porosities they have been prone to plaque accumulation, thus increasing the cariogenic oral flora. Inclusion of carbon nanotubes into heat cure monomer has decreased polymerization shrinkage and has enhanced the mechanical properties. Similarly incorporation of nanoparticles like silver, platinum, titanium and iron have shown increase in flexural strength, antimicrobial properties, surface hydrophobicity, viscoelasticity, decrease in porosity and biomolecular adherence. Although silver nanoparticles have antibacterial activity, their incorporation in acrylic resin have shown a colour change in concentrations above 80 ppm and cytotoxity in concentrations more than 40 ppm. Addition of zirconium dioxide nanoparticles in heat cure PMMA has increased abrasion resistance, tensile and fatigue strength, decrease in water sorption, solubility and porosity. However, the translucency has decreased with the increase in nano zirconium oxide. Ahmed et al using heat cure PMMA with 7% nano zirconium oxide has shown enhanced hardness levels, flexural strength and fracture toughness. According to Gad et al, 2% or 5% nano zirconium oxide has increased the transverse strength of repaired dentures with auto polymerized resin. Addition of 0.4% TiO_2 nanoparticles into 3D printed PMMA denture base has shown significant antibacterial effects especially against Candida species and has also improved mechanical properties.

NANO-CERAMICS

Nano-ceramics have shown improved toughness, ductility and strength as compared to conventional ceramics. NanoGlass ceramics have exhibited good translucency, excellent corrosion resistance, higher hardness and low modulus of elasticity when produced with sol-gel method of zirconia-silica system. NanoTiO_2 ceramics have shown higher toughness and hardness as compared to traditional TiO_2 ceramics. C.H Li et al concluded in their study that nanozirconia ceramics have improved fracture toughness and hardness with addition of up to 20% nanoZrO_2. According to results from an in vitro study ceramics with upto 4% carbon nano tubes (CNT) have significantly improved wear and mechanical properties. Lava Ultimate Resin Nano Ceramic (RNC) blocks (3M ESPE) are innovative new CAD/CAM materials with superior esthetic results, durability and fracture resistance.

TISSUE CONDITIONERS AND SOFT LINERS

Addition of silver nano-particles in these materials have displayed antimicrobial properties against S.mutans and S.aureus at 0.1% and C.albicans at 0.5% after 24 hours incubation period Solutions of chlorhexidine mixed with sodium triphosphate (TP), trimetaphosphate (TMP) or Hexametaphosphate (HMP) were investigated for antifungal property on silicone soft liners and obturators and Chlorhexidine-HMP coating has been proved to be the most effective antifungal agent thus enhancing the life of the prosthesis

IMPRESSION MATERIALS

Impression materials are available now with nanomaterials. Nanofillers in Poly Vinyl Siloxane (PVS) have shown good flow, improved hydrophilic properties and superior detail precision. Trade name Nano Tech Elite HD+(Zhermack). These nanofilled silicone impression materials have shown a high degree of fluidity compared to from the original viscosity. It has been designed to give a snap set with less errors caused by micromovements.

MAXILLO-FACIAL PROSTHESIS

Maxillofacial prostheses have been made of artificial substitutes like silicones. They replace the tissues lost due to trauma or disease, restore and maintain the heath of the tissues and enhance the esthetics. But contamination and infection have given these materials varied clinical results with regards to quality and stability and so nanoparticles have been added to enhance the properties. Addition of silver nanoparticles to these materials has prevented adherence of candida albicans to the surface of these prostheses with no toxic effect to the human dermal fibroblast cells. Titanium dioxide, Zinc oxide and Cerium dioxide nano particles have been added as opacifiers for silicone elastomers and Titanium dioxide and Cerium dioxide nano particles have exhibited the least colour instability. Addition of surface treated Silicone dioxide nano particles in 3% concentration have improved the mechanical properties, especially the tear strength.

IMPLANTS

A lot of research has been conducted to improve the making of implants as a high end treatment modality. The common problems that have been encountered were bacterial biofilm formation on the implant surface which has led to infection, inflammation and implant rejection. Nanotechnology has been widely used for surface modifications of dental implants as it has altered the implant surface at an atomic level thus changing the chemical composition of the surface. This change in the chemistry and the roughness has aided in good osseointegration. Nanostructured hydroxyapatite (HA) coating for implants has promoted bone formation around implants and has increased osteoblasts formation such as adhesion, proliferation and mineralization. Dual layered Silver-hydroxyapatite nanocoating on Titanium alloy implants has created a surface with antibiofilm propeties without compromising the biocompatible HA surface needed for successful osseointegration and accelerated bone healing. Nanoporous ceramic implant coatings has caused anodization of aluminium. This non porous alumina has facilitated osseo- inductive activity. Calcium phosphate (CaP) coating on implant surfaces has increased the osseoconductivity of implants and has shown favourable slow delivery systems of growth factors and other bioactive molecules.

The various surface modification techniques are:

1. Chemical modification:

(a) Anodic oxidation: It has created nanostructures with diameter of less than 100nm on Titanium implants. Voltage and direct current (Galvanic current) have been used to thicken the oxide layer of implant surface.

(b) Combination of acid and oxidants : Combination of strong acids have created a thin grid of Nanopits of diameter 20-40nm on the Titanium surface.

2. Physical modification:

(a) Plasma spray- It has created a nano structure less than 100nm and has enhanced osteoblasts density on implant surface.

(b) Blasting- alumina has been used for obtaining microporosties . Bioceramic grit blasting and acid etching has been the improved version of this technology.

POTENTIAL HEALTH HAZARDS

The toxicity of nanoparticles has been due to greater surface area volume ratio leading to increased absorption through skin, lungs and digestive tract. They easily enter the lungs and reach the alveoli causing inflammation, tissue damage and subsequent systemic effects. These nanoparticles have been transported through the blood stream to the vital organs or tissues throughout the body resulting in cardiovascular and other extra pulmonary effects. Their penetration through the skin may cause cell damage due to the production of reactive molecules.

CONCLUSION

Nanomaterials are playing a significant role in basic scientific innovation and clinical technological change in Prosthodontics. Nanomaterials have captured more and more attention because of their unique structures and properties, such as modulus of elasticity, surface hardness, polymerization shrinkage and filler loading , of materials used in Prosthodontics can be significantly improved after their scales were reduced from micron-size into nanosize by nanotechnology and the performances can be enhanced by adding appropriate nanomaterials.

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